Center for Transportation Technologies and Systems

# Thermal Comfort Project

## A cool solution to the nation's energy security challenges

More people. More cars. More pollution. Our reliance on foreign oil is increasing, as are adverse effects on our energy security, the environment, public health, and driver safety. Everyone recognizes these problems. Less well known is the way much of the oil is being used.

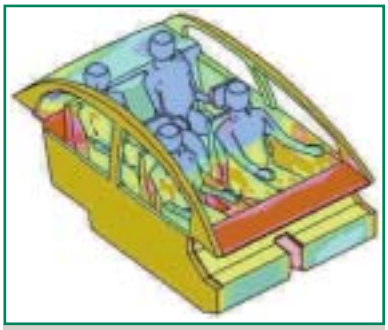
### An Uncool Use of Fuel

A hidden culprit is a car's air conditioning (AC), which alone consumes 7.1 billion gallons of petroleum every year. That's equal to 10% of our annual oil imports, which factors heavily on our nation's energy security. AC can also dramatically increase emissions of pollutants such as carbon monoxide and nitrogen oxides.

The Center for Transportation Technologies and Systems, part of the U.S. Department of Energy's National Renewable Energy Laboratory (NREL), sees this problem as an opportunity. Our approach is to design efficient thermal comfort systems that keep you comfortable, while using less fuel.

### The Thermal Comfort Project

The project goals are to increase the nation's energy security, protect the environment, and enhance comfort-related driver safety, by minimizing fuel use for climate control. Our research on temperature control and human perceptions of thermal comfort will enable us to create thermal comfort systems that maximize occupant comfort and minimize fuel consumption.



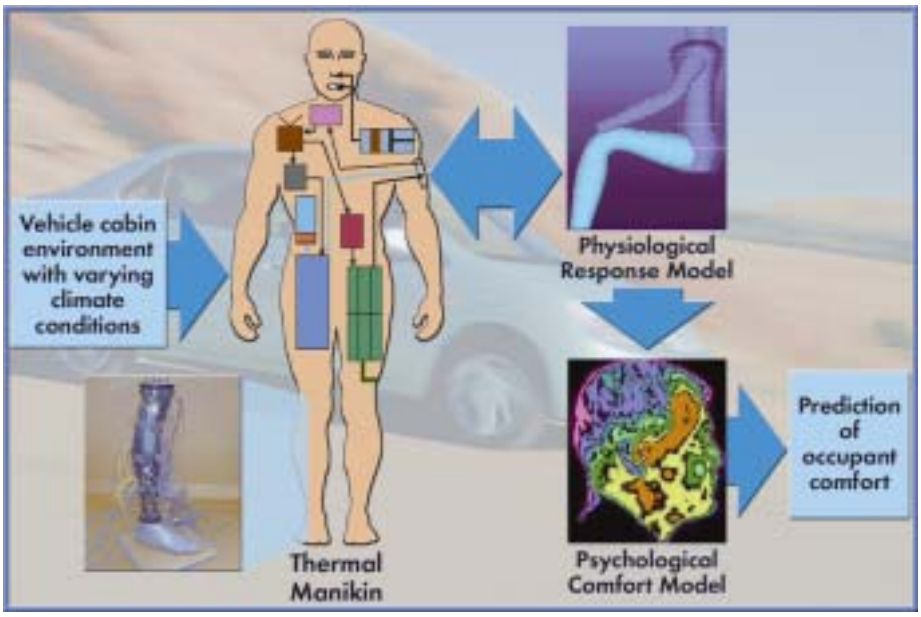
Vehicle cabin thermal simulation

*Produced for the U.S. Department of Energy (DOE) by the National Renewable Energy Laboratory, A DOE national laboratory.*

MEASUREMENT Technology NORTHWEST

## Thermal Comfort Tools

NREL is developing three thermal comfort tools. The tools will measure, predict, and validate human physiological and psychological responses to the transient, non-uniform thermal environment found in motor vehicles.




### *Thermal Comfort Manikin*

ADAM (ADvanced Automotive Manikin) will be the world's most advanced thermal comfort manikin. It mimics human responses such as sweating and breathing. Its high spatial resolution and rapid responses allow the manikin to respond realistically to transient, non-uniform environments. We have constructed a segment of ADAM's leg, which has demonstrated realistic sweating rates, fast transient thermal response times, and high spatial resolution. *Why do we need a manikin?* A large number of human test subjects would be required for the research, so using a manikin saves time and money.

### *Physiological Response Model*

This computer model simulates human physiology and thermoregulatory responses and predicts transient thermal response over a wide range of environmental conditions. Finite element models of organ systems integrate with warm and cold receptors that stimulate responses such as sweating, shivering, and blood vessel dilation. A clothing model simulates the complex interactions between clothing and the human body.

### *Psychological Comfort Model*

NREL's model will be the first to predict thermal comfort under transient, non-uniform conditions. Human subject testing is currently underway at the University of California, Berkeley. The testing will correlate core and local skin temperatures with measures of thermal perception. The resulting computer model will receive information about how hot or cold an occupant *is* and predict how hot or cold the occupant will *feel*.

## Putting It All Together

The three thermal comfort tools work together to predict the comfort of a car's occupants. ADAM can be clothed, placed into a vehicle, and subjected to realistic thermal conditions. It transmits skin temperature measurements to the physiological response model, which predicts local heat generation and sweat rate. ADAM receives these predictions and adjusts its heating and sweating systems accordingly. ADAM transmits the resulting skin temperature back to the physiological response model, and the cycle continues. The resulting body temperatures are transmitted to the psychological comfort model, where the ultimate question is answered: Is the vehicle occupant comfortable? All three thermal comfort tools are scheduled for completion by Fall 2002.

## What's the Next Step?

NREL's thermal comfort research is crucial to the development of effective climate control systems that reduce fuel use. The thermal comfort tools can be used to test innovative systems such as climate-controlled car seats and advanced solar window glazing. Partnering with industry enables innovative solutions to meet specific needs. Most importantly, the improved fuel economy resulting from more effective climate control systems will strengthen our nation's energy security, while protecting our nation's environment, public health, and driver safety.

## *For more information:*

***On the Web***

To find out more about NREL's Thermal Comfort Program, visit our Web sites:

*Thermal Comfort Program*
www.ott.doe.gov/coolcar/assessing.html

*Center for Transportation Technologies & Systems*
www.ctts.nrel.gov/

***Working with Us***

Dr. Rom McGuffin
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, CO 80401
(303) 275-4437
rom_mcguffin@nrel.gov

NREL/FS-540-32285